A Public Health Care Information System Using GIS and GPS: A Case Study of Shiggaon

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Abstract: Health data maps and Geographic Information Systems (GIS) are significant resources for health planning and health services delivery, particularly at the local level. The ability to visualize the spatial distribution of health status determinants and indicators can be a powerful resource for mobilizing community action to improve the health of residents. Currently, health data maps and other GIS applications tend to be highly technical and specialized, and are therefore of limited use to community members and organizations providing community-based health services. Developing relevant, accessible, and usable GIS and health data maps for communities and local agencies is an important step towards enabling individuals and communities to improve their health and increase their control over it. The final map was prepared by overlaying all the layers generated. The spatial objects were digitized out of LISS and PAN merged data and topomap supplied by the NRSA and Survey of India respectively. Questionnaires were prepared to get the data needed from each hospital and house by field investigation. Finally, a map of Public Health Care Information System was created by interlinking all topographical features with attribute data of the town so as to keep this information for planning and development in days to come.

Keyword: public health care system, GIS, GPS

1 Introduction

Health and life expectancy generally improve as societies develop but the major causes of illnesses and deaths will also change. The mapping of

towns and cities (showing health centers, pharmacies, health camps, etc.) and creation of databases using recent technologies have become more significant both as an academic discipline and as one of the foundations for practical decision-making (e.g. in governmental, administrative and other public health care organizations) towards finding solutions of health related problems. It is generally known that the general public does not know where hospitals are located, what facilities and the kinds of specialists are available? Such problems can be addressed effectively by mapping and creating relevant databases using a GIS.

The call for streamlining of health care operations as a means of achieving greater cost-efficiency is a positive sign in the development of a society. Community leaders searching for innovative methods for health care management have begun to recognize the power of a GIS in various management activities ranging from determining intervention strategies to formulating health care reforms. Through the geo-coding process, a GIS allows personal health data to be examined spatially so that patterns can be discerned. Furthermore, geo-referencing of personal health data can greatly enhance decisions made by public health officials. The tremendous potential of a GIS to benefit the health care industry is just now beginning to be realized. Both public and private sectors (including public health department, public health policy and research organizations, hospitals, medical centers, and health insurance organizations) are beginning to harness the data integration and spatial visualization power of a GIS.

A GIS plays a critical role in the decisions on where and when to intervene, improving the quality of care and accessibility of services, finding the most cost effective delivery modes, and protecting patient confidentiality while satisfying needs of the research community on data accessibility. The GIS technology has been used in public health care for epidemiologic studies, as in tracking the sources of diseases and its spread in the communities such that authorities can respond more effectively to outbreaks of diseases with appropriate intervention measures to the at-risk population. GIS Applications in public health include tracking of child immunizations, conducting health policy research, and establishing health service areas and districts. A GIS not only provides a way to move data from the project level to become a ubiquitous resource for an entire organization but also renders the visualization of clinical and administrative data as a spatial decision support tool.

As towns have grown larger as a result of urbanization and industrialization, the concentration of population has in turn led to complicated health issues. A proper understanding of the roots of health problems is essential. In this connection, an understanding of the spatial occurrences of various diseases in urban area is a must for rational planning and management.

Knowledge about characteristics of the population and the diseases can be derived from GIS and Remote Sensing technologies.

Many health-related problems and determinants in the North Karnataka state of southern India have been discussed in research papers. These papers also shed light on causes, differential incidence and socio-spatial consequences of ill health within the towns. The town of Shiggaon, a taluk headquarter, was selected for this research. Shiggaon is situated between latitudes 14°59'24"N and 15°00'02"N and longitudes 75°12'36"E and 75 °13'48"E (Figure 1). The total study area measures 20.74 sq. km. with an annual precipitation of about 350 cm. Precipitation occurs in two seasons, mainly between June and September as well as between October and November. The mean annual temperature ranges from 22.8°C to 27.8°C. The population of Shiggaon consists of Hindu (70%), Muslim (29%), and others (1%). Socio-economic, demographic, and standard of living data of Shiggaon's population were gathered by questionnaire surveys. Projections on human needs were also made.

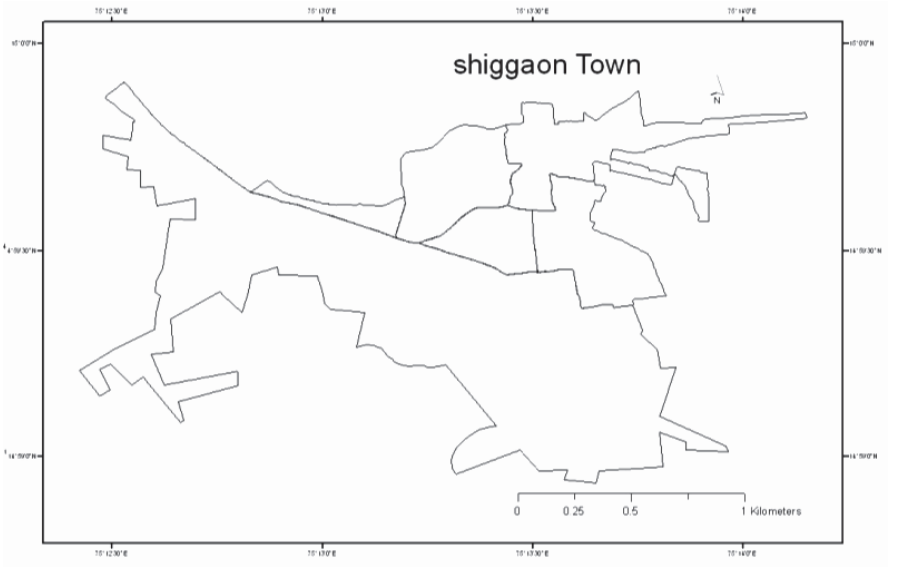

Fig. 1. A location map of Shiggaon town

The research aims at mapping Shiggaon to show the distribution of hospitals, clinics, and dispensaries, in addition to assembling a database on them. The public health care system concerns not only the health, well-being, and functioning of the population but also offers the ability to visualize spatial distribution (e.g., ward-wise) of health status indicators and other health-related information (Figure 2). Both GPS and ArcGIS soft-

ware were used to demarcate the town's boundaries, locate hospitals and delimit disease vulnerable zones (Figure 3). Here, a GIS was used to collect, integrate and display population-based data concerning health events (including disease exposures, risk factors and socio-economic data).

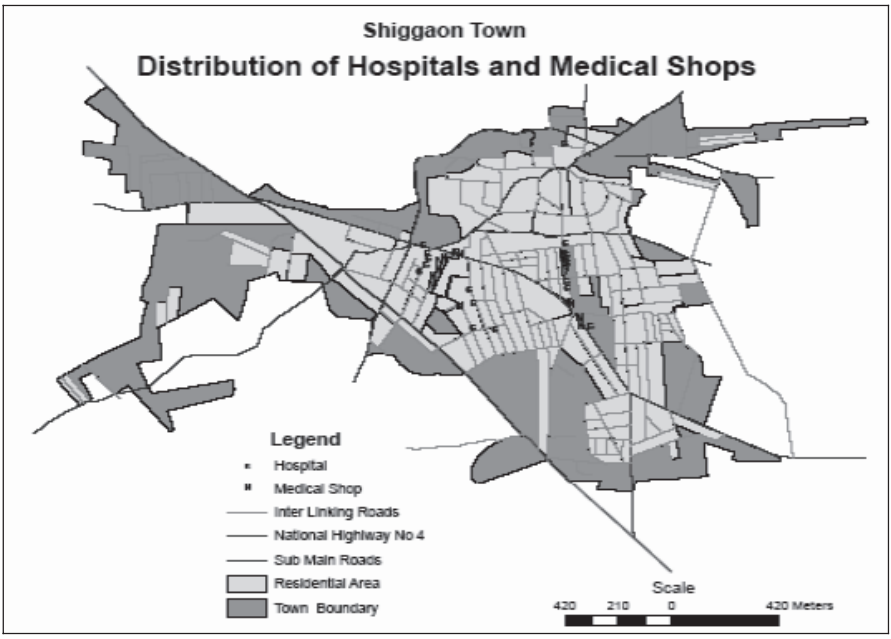

Fig. 2. Distribution of hospitals and medical shops

Developing a GIS with the relevant health data that are accessible and useable by the communities and local agencies are important steps toward realizing the goal of enabling individuals and communities a better control over their personal health. A GIS provides a supportive environment for population-based public health program planning, program evaluation, and community based decision-making. In the end, health-related information will be available for the public of Shiggaon located in the western parts of middle Karnataka (India) in the Haveri district.

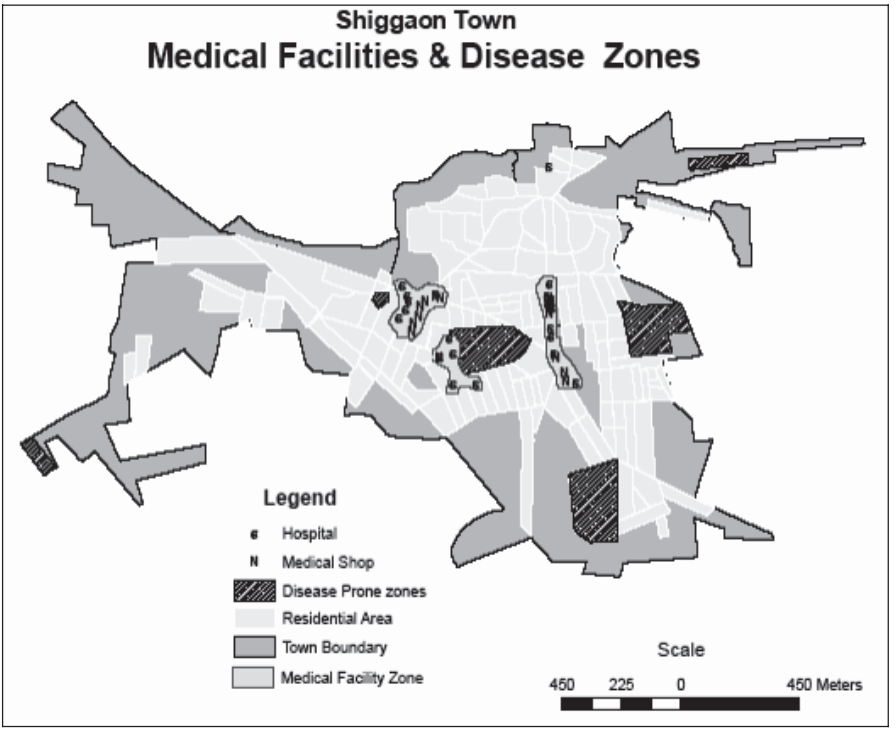

Fig. 3. Medical facilities and disease zones

2 Major Diseases in Shiggaon

2.1 Heart Related Diseases

WHO and various health organizations declared 2006 as the year of prevention. A major disease for prevention in Shiggaon is the cardiac disease and sudden cardiac death as these diseases have been spreading rapidly and reaching epidemic proportions. A 2005 survey of the 25-60 age-groups of Shiggaon revealed that half of the total death was from heart attack and heart-related problems. An even more startling fact is that one fourth of those with heart problems never reached hospitals to receive definitive treatment. If this was the fate of the population of a medium sized town, imagine the plight of people in the traffic chaos of Delhi, Mumbai, Kolkota, Chennai, Bangalore, and Hyderabad. Cardiologists have indicated that individuals with prior records of a heart attack have a higher risk of subsequent attacks. Given that the conditions of a heart attack patient can

deteriorate very fast, adequate facilities must be made available to meet this kind of emergency. Angioplasty services should also be made available in each town to rid the need of patients going to major cities for treatment, which incurs much time and cost.

Preventive steps to avoid a heart attack, such as blood tests to detect the disease risk, are essential services. In addition, CT Angiography, a simple and noninvasive procedure to test the blockage in blood vessels, should be made available to individuals at risk. These individuals would include men over the age of 40, women over the age of 50, patients with diabetes mellitus and/or hypertension, obese individuals, smokers, and those with a family history of heart attacks. Such CT Angiography facilities are now only available in larger cities and not in towns.

2.2 Diabetes Mellitus

A recent survey conducted in Shiggaon indicated that 4 per cent of the town's population has Diabetes Mellitus, of which around 20 per cent are adults. The major causes of this disease are bare foot walking and the rapid onset and spread of infection once the foot sustains an injury. Foot problems have remained one of the most serious and expensive complications of Diabetes Mellitus and the divesting effects are already felt in Shiggaon. While advances in health care can help in early detection of the disease, educating the public on preventive measures are a must. For example, one should not walk barefoot indoor as well as outdoor and use correct footwear as prescribed by physicians. A daily inspection of the feet for blisters, wounds, bleeding, smell, or increased temperature is also recommended.

2.3 HIV/AIDS

Acquired Immune Deficiency Syndrome (AIDS) was first recognized in 1981. A large proportion of adults and children are infected daily. Because of high fatality and the lack of effective treatment or vaccine, the HIV/AIDS has emerged as one of the most serious health problems in India. In terms of income and wealth, AIDS has been found to associate with poverty and ignorance in Shiggaon. The percentage of HIV infected people living in the town should be higher than that reported officially as many are not aware that they are infected according to statements made by physicians. There were reportedly 55 confirmed AIDS cases in 2005 and about 20 percent HIV infected individuals in Shiggaon, according to sources from local hospitals.

Epidemiological studies have demonstrated that the major routes of HIV transmission are sexual intercourse, intravenous injections and transmissions from infected mothers to unborn fetuses through the placenta. Female Sex workers in Shiggaon have a significant level of HIV infection. A well-established National Highway No.4 which transects the town is known to be a major site of transmission of the virus where contact between sex workers and drivers is common. Increasingly, HIV is found to associate with sexually transmitted diseases (STDs) and tuberculosis, compounding an already alarming public health problem in Shiggaon. Unless serious preventive interventions are undertaken, there is a great potential for further acceleration in HIV prevalence.

The situation in Shiggaon can be summarized as follows. Firstly, HIV infection is rapidly spreading beyond the few high risk areas and exhibiting different epidemiological stages within the town. Secondly, interaction between HIV and sexually transmitted diseases and Tuberculosis is widely prevalent in the town, presenting an even more challenging public health problem. Finally, the co-relation between HIV and tuberculosis may result in a resurgence of tuberculosis.

2.4 Malaria

Malaria is a major health problem in Shiggaon where the carrier Anopheles mosquito breeds in stagnant pools of water due to poor sanitation and drainage. Other vector–borne diseases, such as dengue hemorrhagic and yellow fever, are associated with the need of households to store water in iron drums or earthenware containers which provide ideal breeding conditions for the Aedes Aegypti mosquitoes. The scarcity of clean water and lack of sanitation make diarrheal diseases a major health problem, while a variety of intestinal parasites, such as ascaris (roundworm) and trichuris (whipworm), are usually present. The crowded living condition also increases the risk of meningococcal meningitis, which leads to a high incidence of preventable infections in children such as measles, whooping cough and polio.

2.5 Tuberculosis

Tuberculosis is a contagious bacterial disease occurring in several forms in slum pockets of urban areas. It was once a common disease in Shiggaon but now found in migrant population returning from work in major cities of India. Major symptoms of Tuberculosis are fever, loss of appetite/weight, lack of energy, coughing, loss of color, irritability, and severe

sweating at night. There were only a few cases of Tuberculosis diseases reported in 2005 by Government hospitals. However, studies have found that children under two and young women are more vulnerable than men or older people. There is no home treatment for Tuberculosis but the disease responds well to modern drugs. The key to avoid this potentially serious disease is frequent Tuberculosis screening.

3 Determinants of Public Health in Shiggaon

Awareness and behavior of the people play a vital role in disease prevention. The level of education of the mothers and the ability to read and comprehend health-related literature are keys to keeping family members healthy. Physical environment such as the residential location and its geographical surroundings has a direct influence on the health conditions of members of a family and the communities. Socio-economic conditions like income, education, religion are reflective of the conditions of health. All in all, air and water qualities, as well as the physical location of a settlement contribute collectively to the health of the people. Apart from these, biological and structural factors like age and gender or laws and norms play a vital role in the assessment of health care needs of the people.

The educational level of the residents of Shiggaon dictates their hygienic practices. About 30% of urbanities in the study area are illiterate and hardly resort to hospitals for their health problems. Water sources and sanitation facilities have an important influence on the health of urbanities. About 72% of households use piped drinking water, 15% use well water, and 13% use hand pumps. 50% of households either have a source of drinking water in their residence/yard or take less than 15 minutes round-trip to obtain drinking water. Only 60% of the town's population purifies their drinking water by some methods, including straining by cloth, filtering and boiling. The urbanities hardly use electronic appliances for water filtration and there is no proper treatment of drinking water by the local government.

With regard to sanitary facilities, the residents have hardly flush-type toilets and use either piped water or water from a bucket for flushing. Most of the urbanities have a pit drop toilet or latrine. However, close to 30% have no access to sanitary facilities, thus creating a lot of unhygienic conditions in the town.

4 An Integrated Approach to Health Care

An integrated approach is proposed here to bring together a range of health and other initiatives to produce an outcome in Shiggaon. Health improvement is seen only as a part of the integrated approach whose goal is total development of the community. This approach resembles the concept of a comprehensive Public Health Care (PHC) despite its potential need for building systematic linkages between physical improvements, social services, and resident participation.

Community participation is a key principle in an integrated approach. Environmental improvements may require some residents to give up parts of their plots or buildings to allow streets and drainage lines to be installed. Failure to consult local communities in advance often leads to a subsequent lack of cooperation and problems of ongoing maintenance of new infrastructures. Consent of the community, however, ensures that changes are more likely welcome, understood and longer-lasting which can also generate community spirit and promote local self-help. The potential of a grassroot-based integrated community development program is to be undertaken in Shiggaon. The local government and Non-Government Organizations (NGOs) are expected to mobilize local laborers and resources to develop an integrated program based on initiatives, physical upgrading, community development, and awareness of HIV/AIDS and other common diseases in the town. An effective implementation of the community development initiatives will require coordinated actions between the service providers and the intended recipients.

The complexity of poverty-related problems in the most deprived urban communities - including low levels of education, limited resources, and unfamiliarity with urban power structures - undermines the inability of the poor to mobilize resources for their health needs. Neither the NGOs nor private voluntary organizations (PVOs) can play a leading role in promoting community development. A public-private partnership between a city health authority and an NGO or PVO can provide the latter with a micro-scale perspective and framework for replication of successful projects. Public agencies will benefit by gaining a trusted mode of entry into the community and a means to deliver community-based PHC services with an emphasis on prevention as opposed to the more common facility-based curative care.

Figure 4 illustrates the processes to care for the health of urbanites in town. These processes involve a coordinated effort. Here, a technical team develops a respiratory health data model to facilitate identification and assessment of candidate data sources. The model attempts to describe the re-

lationship between determinants and indicators of respiratory health. Criteria for evaluating candidate data sources were developed from a comprehensive metadata model developed for the project which included the following aspects of a data source: quality, completeness, relevance, ease of integration, potential for misinterpretation, and cost (if any).

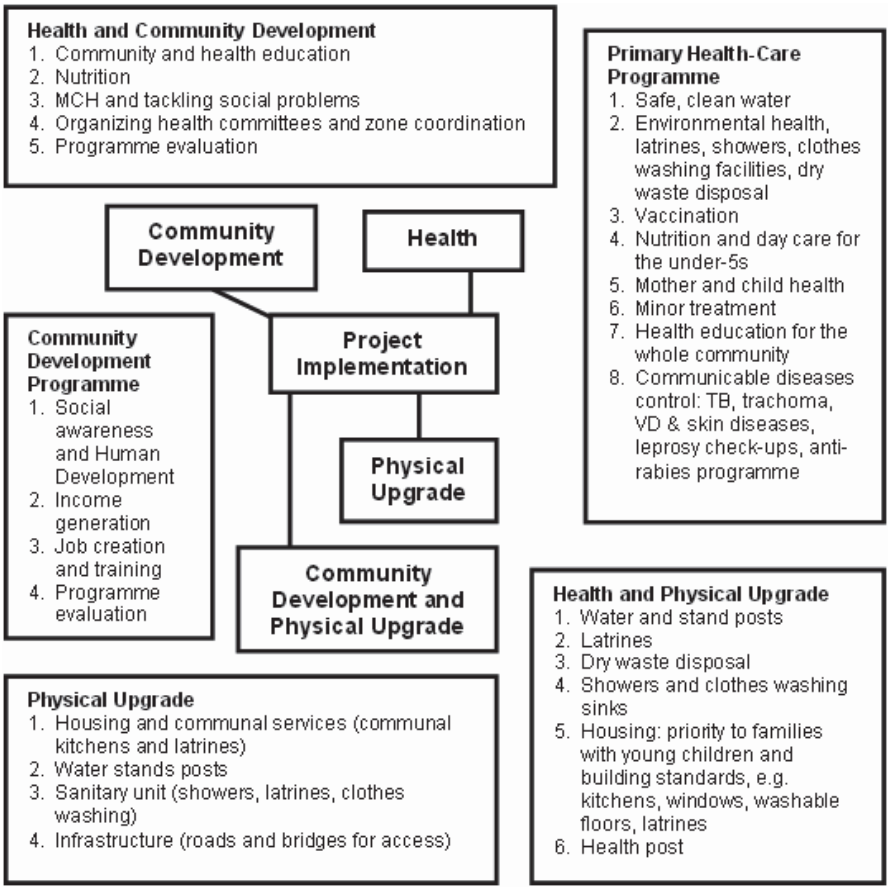

Fig. 4. The iterative process used to develop the health of urbanites in the town

5 Primary Health Care

The concentration of health resources and the relative proximity of hospitals and other medical facilities in cities have meant inconvenience to those living in towns as compared to those living in cities. Given that health-care services target preventive medicine, the underlying causes of ill health are

unlikely to be addressed adequately. Primary Health Care (PHC) has emerged as the favored response to health care provisions in the towns.

At the heart of the PHC approach are the principles of equity in distribution, community involvement, a focus on prevention, use of appropriate technology, and a multi-sectoral approach that acknowledges the multiple aetiology of health problems. Major constituents of the PHC strategy include education about diseases and their controls, provision of safe water and basic sanitation, and measures to provide better maternal and child care, such as family planning, immunization against major infectious diseases, treatment of common diseases and injuries, and provision of essential drugs. Some have argued that this form of comprehensive PHC is idealistic and unattainable in a Third World city because priorities must be identified for reasons of practicality, cost and effective use of available resources given extensive health problems of varying severity.

6 Results and Discussions

Shiggaon has three distinctive seasons: (i) cold (winter) from October to March; (ii) hot (summer) from April to mid-June; and (iii) rain from mid-June to October. The town receives 85% of its rain from the southwest monsoon and 15% from the northwest monsoon. The general health conditions of its residents are from moderate to poor mainly because of poor sanitary conditions, drinking water, drainage etc. The proportion of preventive and curative clinical services is not up to the national mark and the amount of health services and programs are inadequate. The health and family welfare of Shiggaon are provided through a network of government or municipal hospitals and dispensaries and urban family welfare centers. Private hospitals, clinics and dispensaries also play a major role in providing these services to urbanities. While Shiggaon is not lacking of hospitals and clinics, these facilities are not well equipped to prevent occurrences of some diseases.

An important development took place when India adopted the National Health Policy in June 1981. This development may be viewed as an outcome of the declaration of health issues of the International Conference on Primary Health, jointly sponsored by the World Health Organization and UNICEF in Alma Ata in 1978 (World Health Organization and UNICEF, 1978). Although the National Health Policy places a major emphasis on ensuring primary health care to residents of all towns in India, it nevertheless identifies certain areas needing special attention in Shiggaon, as listed below.

1. Nutrition for all segments of the population
2. Immunization programs
3. Maternal and child health care
4. Prevention of food adulteration and maintenance of quality of drugs
5. Water supply and sanitation
6. Environmental protection
7. School health programs
8. Occupational health services, and
9. Prevention and control of locally endemic diseases

The healthcare system of Shiggaon is not reaching its intended population of 27,500 with another 50,000 living in its hinterlands. It also faces the risk of not having enough health workers to take care of the huge population. There is thus a need for a holistic approach to cater to the health care demands of its population. Anti-smoking measures, blood pressure and diabetes management advisories have been ignored by its residents who embrace a life of darkness and constant threat to healthy living. Despite efforts by government operated hospitals and private medical establishments in the town, there is little awareness on preventive health care. The fact is that people take their health for granted and are not bothered to obtain health insurances for preventive care. At the other end, water and garbage waterlogged soils are ideal for transmitting diseases such as hookworm. Likewise, pools of contaminated standing water provide breeding grounds for mosquitoes that convey enteric diseases like filariasis and malaria. Clearly, there is an urgent demand to improve the hygiene conditions through various measures, such as offering loans to households for upgrading shelters, granting supplies of cheap and easily available building materials, improving sanitary situations, and providing clean water supplies.

7 Conclusion

Population health is an emerging framework for assessing and evaluating the health status and health outcomes of a defined population. It is in many ways a superset of public health functions and goals. A GIS is an integral and essential component of a comprehensive population health information system. It is however a tool rather than an end in the practice of population health. The local government of Shiggaon has to take care of the general health welfare and prosperity of its residents by regulating the physical

growth of the town and providing essential infrastructures for roads, water and sewerage. There is also the need to stimulate economic development, provide health education, and secure publicly accessible recreational opportunities. In doing so, the local government channels a variety of private interests toward decisions and policies about health and to protect public interests. The local government's efficiency, effectiveness and accountability must be improved in order to provide better health services to the people of Shiggaon. Nonetheless, active participation from the community is needed for the successful implementation of an integrated health program.

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